CALCULATING MU () LAB

Name \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

1. PURPOSE

(1) To measure the static coefficient of friction for several angles on an inclined plane.

(2) To study equilibrium and non-equilibrium of a body on a frictionless inclined plane under the action of forces.

**MATERIAL**

Inclined planes at 30**°** degrees, 45**°** and 60**°**.  
wooden blocks with sandpaper   
small cart with wheels   
set of weights  
pulleys  
string  
Spring scales   
C clamps

3. BACKGROUND

Source: Physics and Physical Science Demos, Labs and Projects. <https://teachingphysics.files.wordpress.com/2010/12/measuring-the-coefficient-of-friction-labquest.doc>

The coefficient of friction is a ratio that is calculated by dividing the force to overcome friction by the weight of an object. When an object is at rest, there is a cohesive force, like the object is glued to the surface. It takes extra force to break this bond and start and object moving. This frictional force is called “static friction.” Once an object is moving, it requires less force to maintain a constant speed. The frictional force of a moving object is called “kinetic friction.” Kinetic friction is usually less than static friction because it usually takes less force to keep an object moving once it starts moving.

To study static friction, we can use an inclined plane. As the angle of inclination is increased from zero, the component of the block’s weight pointing down the plane increases. Because of the variable nature of static friction, the magnitude of the friction force keeps increasing as the ramp is raised.

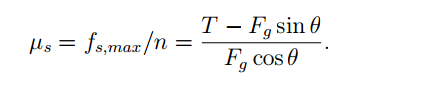
A similar procedure may be used to measure the parallel component of gravity of an object sitting on an inclined plane by using “frictionless” carts which are placed on an inclined plane. A pulley at the end of the incline is used to redirect the forces to a set of hanging weights until equilibrium is reached.

4. PROCEDURE

You are responsible for data from only one inclined plane (30 degree, 45 degree or 60 degree)

1. **Starting friction on the inclined plane**.

Attach your inclined plane to a lab table using two C clamps.  
Use the spring scale (either electric or spring) to measure the weight in Newtons of the wooden block.  
Lay the wooden block on the plane with its sandpaper face down. Each team will use a different angle (30 degrees, 45 degrees or 60 degrees.)  
Apply a force, P, to it by means of a string running over a pulley to a brass weight. Add weights to the hanger until the block begins to move. In this way determine the approximate value of starting friction. Determine the value more accurately by starting just below this value and adding weight in very small increments. The error may be estimated by noting the smallest additional weight which produces motion. Remember to convert the masses in kg into Newtons. This weight represents the parallel component of the weight (mgsinΘ) minus the force of friction.

Calculate the coefficient of static friction by using the formula:

In this case, T (tension in the string) = the value of the brass weights on the string in Newtons  
Fg equals the mass of the wooden block in kg times 9.8 N/kg  
The sine and cosine of the angle will depend upon which ramp you have used.

When you have finished with your ramp, you are to use Excel to plot   
T- F**g**sinΘ against F**g**cos Θ

Ask Excel to give you a line of best fit and a regression formula for this line. The slope will be µ

**(2) Equilibrium on the Inclined Plane.**   
Investigate the parallel component of gravity on an inclined plane using the frictionless carts.   
Use the spring scales to measure the weight of one cart. Add 500 grams to this cart and enter the total weight in Newtons on your data table. Attach a string to the cart and run the string over the pulley. Tie a paper clip or make a loop on the end of the string so that you can place different weights onto the string.

Add weights until the cart just starts to move as mentioned above. Convert your masses in kg into Newtons and record on the data table. Repeat this several times using a starting weight of 300 grams in the cart and then 100 grams in the cart. Since we assume that the cart is frictionless, the coefficient of friction is zero or minimal. Use the formula above to compare the parallel and normal forces. If time allows, you may graph them in Excel as well.

**Wheeled Cart Data**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Plane Angle (degrees) choose one | Mass Added to Cart (kg) | Hanger Mass, Cart Moving Up (kg) | Hanger Mass, Cart Moving Down (kg) | Hanger Mass Average (kg) |  |
| 30/45/60 | 0.100 |  |  |  |  |
| 30/45/60 | 0.300 |  |  |  |  |
| 30/45/60 | 0.500 |  |  |  |  |
| Plane Angle (degrees) Choose one | Total Cart Mass (kg) | Total Cart Weight (N) | Calculated Parallel Force (N) [mgSinΘ] | Experimental Parallel Force (N) | Percent Difference (%) | () |
| 30/45/60 |  |  |  |  |  |  |
| 30/45/60 |  |  |  |  |  |  |
| 30/45/60 |  |  |  |  |  |  |

**Wooden Block Data**

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Block type: | | | Mass (kg) | | | Weight (N) | |  | | Hanging mass | | |
| Trial 1 | | |  | | |  | |  | |  | | |
| Trial 2 | | |  | | |  | |  | |  | | |
| Trial 3 | | |  | | |  | |  | |  | | |
| Plane Angle (degrees)  Choose one | Total block Mass (kg) | | Total Block Weight (N) | Calculated Parallel Force (N) [mgSinΘ] | | Experimental Parallel Force (N) | | Percent Difference (%) | | () |
| 30/45/60 |  | |  |  | |  | |  | |  |
| 30/45/60 |  | |  |  | |  | |  | |  |
| 30/45/60 |  | |  |  | |  | |  | |  |

1. 6. WRAP UP QUESTIONS
   1. Give two examples in real life where friction is helpful Give two examples in real life where friction is detrimental (harmful)
   2. How did this lab help you compare the normal force to the parallel force?
2. (4) What were you sources of error? (5) How could you reduce the coefficient of friction in the wooden block part of the lab?
3. Explain why the coefficient of static friction is greater than the coefficient of kinetic friction?
4. Why must you pull the object under test at a constant speed? What happens if you don’t?
5. What additional surface/material combinations would you like to test for their coefficient of friction?
6. What could you have done in this lab to improve the accuracy of your results?
7. What should be done to improve this lab for next year’s students?
8. Graphs (print out and attach)